22. The combined seal is said to be highly effective for smoke control on doors tested to BS 476, Part 31.1 and equivalent standards.

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RESEARCH

FULL-SCALE THREE-STOREY HOUSE BURNED IN JAPANESE TEST

On 4 December 1991 one of the most impressive full-building fire tests of recent history was conducted in Japan. The test building comprised a portion of a three-storey apartment building and was built $1^1/_2$ units wide; that is to say, the test building included three complete apartments, flanked on one side by three smaller units.

Each apartment, in the Japanese style, comprised a large living/dining/kitchen room, a traditional 'tatami mat' room adjacent, separated by a sliding ricepaper fusuma door. In the back of the apartment was a hallway, a single bedroom, closets and bath facilities. Both the front of the building and the exit hallway at the rear had open balconies, except on the first floor which was glazed.

The building was constructed of wood in a slightly modified American style, using '2 × 4' (50 × 100 mm) timbers. The interior walls comprised two layers of 12 mm gypsum board. The outside of the building was sheathed in a cement/'Excelsior' board common in Japan.

The Japanese Ministry of Construction undertook the experiment to determine whether the American-style construction could meet fire and earthquake safety levels sufficiently to be used in Japan. The work stemmed from a trade agreement negotiated between Japan and the USA (see *FFB*, September 1991), which was to allow three-storey wood construction apartment buildings to be built in the less dense regions of Japan. Of special interest to the Japanese was the building's post-earthquake fire performance, a topic of much interest there following the great Kanto earthquake in the 1920s, when much of Tokyo was burned down.

The tests

Prior to the fire test, the building was subjected to a very severe earthquake test. This was done by attaching large hydraulic rams to the building and conducting a number of push–pull cycles, the largest being set to produce a 1/100 horizontal displacement of the second-storey floor. Quite impressively, only minor cracking was found after the earthquake test, and no chunks of gypsum board fell off.

The fire test involved about 35 kg/m^2 of fuel load being distributed throughout the three full apartments. In the first floor apartment of fire origin, mostly realistic furnishings were used, with wood cribs being substituted in the upper two apartments. Within the room of origin, the fire developed rapidly and, interestingly, averaged near the ISO 834 temperature/time curve for the 1 h period. The success of the experiment lay in the fact that at no time during the 1 h test did the fire spread beyond the apartment of origin; in fact, the fire, while thoroughly burning out the front two rooms, did not even involve the back bedroom (see Figure 1).

After the 1 h period passed and a successful result was seen, orders were given to the attendant fire department crew to forcibly explore the results of wider spread. Thus, the crew entered and created

FIGURE 1: View of test house at end of 60 min fire test. Note the unbroken windows of the upper storeys, indicating the effectiveness of balconies and 'eyebrows' in preventing the fire from spreading into the apartment above.

a hole in the floor of the apartment above and also broke or opened a number of windows. After the desired observations were made and another 30 min had elapsed, the fire was extinguished. Later in the day, the structure was re-used to make a test of residential sprinkler performance.

Fire contained within apartment

Perhaps the most remarkable demonstration in this study, witnessed by some 1200 guests and observers, was the safety of the adjoining first-storey half-apartment. During the entire 1 h period, two fire officers remained in that apartment, taking notes and making observations, without needing to don any protective breathing apparatus.

One factor contributing to the good performance of the test structure was the fact that balconies or 'eyebrows' were used throughout. protecting upper-storey windows from flames coming from windows below. This architectural feature is very common in Japan, but is somewhat uncommon in Western building practice.

These experiments were conducted at the fire test ground of the Building Research Institute in Tsukuba. It is expected that Dr Yuji Hasemi, the project leader, will release a detailed report on this burn test during the first half of 1992.

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